Identification of Process Hazards and Accident Scenarios for Site 300 B-Division Firing Areas

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1.0 Introduction

This report describes a hazard and accident analysis conducted for Site 300 operations to support update of the Site 300 B-Division Firing Areas Safety Analysis Report (SAR) [LLNL 1997]. A significant change since the previous SAR is the construction and the new Contained Firing Facility (CFF). Therefore, this hazard and accident analysis focused on the hazards associated with bunker operations to ensure that the hazards at CFF are properly characterized in the updated SAR. Hazard tables were created to cover both the CFF and the existing bunkers with "open air" firing tables.

The analysis was based upon information gathered from the following key sources.

- The existing SAR [LLNL 1997],
- The Facility Safety Procedure (FSP) [LLNL 2000a],
- Operational Safety Procedures (OSPs) [LLNL 200b, LLNL 2000c, LLNL 2000d, LLNL 2000e, LLNL 2001],
- Walk-through of the CFF,
- The Safety Question Review for CFF qualification testing [Ingram 2000],
- A description of the Contained Firing Facility [Visoria 2001],
- Ongoing discussions with subject matter experts including:
 - Jim Lyle, B Division/CFF Laboratory Associate/PSAR Author,
 - Jack Lowry, West Area Supervisor,
 - Kent Haslam, B Division Site 300 Facilities Manager,
 - Carl Ingram, Assistant B Div. Leader for ES&H,
- Witnessing of a shot at Building 851 which included informal briefings by bunker staff,
- A meeting with bunker staff after the witnessed shot to discuss residual questions.

1.1 Acronyms Used in this Report

CFF Contained Firing Facility, Building 801

LLNL Lawrence Livermore National Laboratory

H&S Manual The LLNL Health and Safety Manual UCRL-M-133867 [LLNL current]

SAR Safety Analysis Report

2.0 Hazard Identification

Hazard identification was based upon Table 2 of the LLNL H&S Manual, Supplement 6.06. Each of the hazard sources in this table was considered to identify hazards that are beyond those associated with activities commonly performed by the public. Table 1 Lists the specific hazards identified.

The different areas and operations that represented substantially different hazard conditions were identified based upon a consideration of facility layouts and operations. Table 2 lists the locations identified, Table 3 lists the operations identified.

For each location the list of specific hazards was reviewed to identify the operations during which a specific hazard would be present. The result was table 4.

Table 1 Non-routine hazards of bunker operations

Hazard Sources	Specific Hazards	Hazard Sources	Specific Hazards
Flammable Materials	Mobilelift or Forklift: Batteries, Hydraulic fluid	Rotating equipment	Cameras
	Electrical equipment	Shears, sharp edges	N/A
	Solvents	Pinch Points	N/A
	Fire in or around service building	Vehicles	Mobilelift or Forklift: Mechanical Impact
Toxic Materials	Toxic explosion by products	Mass in motion	Shrapnel from shot
	Beryllium	·	Shrapnel from tire blowout
	Highly Toxic Materials		Blast effects and shrapnel from shot
Reactive Materials	HE accumulation in systems		Test launcher or gun
Oxygen Deficiency	Explosion creates oxygen diffident atmosphere		Liquid abrasive cutters
	Inert or toxic gas systems		Shrapnel from camera failure
Carcinogens	N/A	Falling	Equipment Falling on HE
Intense Light	Flash Devices	Falling Objects	Diagnostic or setup equipment falling on HE
Lasers	Diagnostic lasers	Lifting	Dropped HE
	Experimental lasers	Tripping, Slipping	N/A
Ultraviolet	N/A	Earthquakes	Seismic Event
X-rays	X-ray machines & linear accelerators	Steam	N/A
Infrared	N/A	Fire	Equipment
Electron Beams	N/A	Solar	N/A
Magnetic Fields	N/A	Chemical Reactions	Chemical reaction with assembly materials
RF Fields	Portable Radios	Spontaneous combustion	N/A
Nuclear Criticality	N/A	Cryogenics	N/A
High Energy Particles	N/A	Ice, snow, wind, rain	N/A
Capacitors	FXR	Heaters	Preconditioning heaters
	Flash Device Power Supplies	Confined gases	N/A
Transformers	N/A	Explosives	Unreacted HE after test
Exposed Conductors	N/A	Noise	N/A
ESD	Tools	Pathogens	N/A
Lightning	Lightning	Allergens	N/A

Table 2 Bunker areas containing significantly different hazards

Firing Table, CFF Firing Chamber

CFF Grey Area

CFF Diagnostic Equipment Room

CFF Diagnostics room penetration area

Bunker / CFF Control Room

Camera Room

CFF vent duct areas

Table 3 Bunker operations posing significantly different hazards

HE Transport	HE present in area but not secured to test stand. Vehicles may be present on firing table or in firing chamber
Shot setup	HE present but not being moved, prior to muster
Shot	Period during which personnel are mustered under cover
Post shot	Period from the point when personnel leave cover until firing table is declared secure
Camera operations	Period when high speed streak cameras are running
Continuous	All operations

Table 4 Summary of hazard exposure

Specific Hazards	Firing Table, CFF Firing Chamber	CFF Grey Area	Diagnostic Equipment Room	Diagnostics room penetration area	Bunker / CFF control room	Camera Room	CFF vent duct areas
Mobilelift or Forklift: Batteries, Hydraulic fluid	HE transport	HE transport		1			
Electrical equipment	Shot setup						
Solvents	Shot setup						
Fire in or around firing table or CFF service building	HE transport Shot setup	HE transport					
Toxic explosion by products	Post shot	Post shot	Post shot	Post shot		Post shot	Post test
Beryllium						Camera operation	
Highly toxic material contained in experiments	Shot setup						***
HE accumulation in systems	Shot setup Post shot						
Explosion creates oxygen diffident atmosphere	Post shot	Post shot	Post shot	Post shot		Post shot	Post test
Inert or toxic gas systems				Continuous			
Flash Devices	Shot setup						
Diagnostic lasers	Shot setup						
X-ray machines, linear accelerators					Shot		
Portable Radios	Shot setup						
FXR							
Flash Device Power Supplies	Shot setup						
Tools	Shot setup						
Lightning	HE transport	HE transport					
Cameras							
Mobilelift or Forklift: Mechanical Impact	HE transport	HE transport					
Blast effects and shrapnel from shot		Shot	Shot	Shot	Shot	Shot	
Shrapnel from tire blowout	HE transport	HE transport					
Test launcher or gun	Shot setup						
Shrapnel from camera failure						Camera operation	
Liquid abrasive cutters	Shot setup						
Equipment Falling on HE	HE transport	HE transport					
Diagnostic or setup equipment falling on HE	Shot setup						
Dropped HE	HE transport	HE transport					
Seismic Event	HE transport	HE transport					
Equipment	HE transport	HE transport					
Chemical reaction with assembly materials	Shot setup						
Preconditioning heaters	Shot setup						
Unreacted HE after test	Post shot						
HE with attached detonators	Shot setup						

3.0 Hazard Analysis

For each combination of location and operation, each relevant specific hazard was considered. One or more deviations were identified which would cause each specific hazard to be realized as a hazardous event and the possible causes for these deviations were described. The deviations, together with the cause describe an event scenario. The worst-case consequences were identified for each event scenario together with the possible methods of detecting, preventing, and mitigating the event. The results of this analysis are given in Appendix A.

A simplified summary of this analysis was incorporated into the SAR update by grouping the analysis according to common hazard scenarios and providing more general descriptions of the causes, methods of detection, preventative features, consequences, and mitigative features. The last column of the Appendix A tables identifies the associated summary hazard scenario given in the Table 4-2 of the updated SAR.

4.0 Risk Assessment

Simple event trees were constructed for each hazard scenario in the updated SAR to help in the qualitative assessment of event occurrence probabilities. Appendix B contains these event trees. Each event in an event tree was classified into one of the probability categories shown in Table 5.

Table 5 Probability rating levels

Category	Description	Estimated occurrence rate per year
Incredible	Probability of occurrence is so small that a reasonable scenario is not conceivable	< 10 ⁻⁶
Extremely low	Probability of occurrence is extremely unlikely or event is not expected to occur during the life of the facility or operation	10 ⁻⁶ to 10 ⁻⁴
Low	Probability of occurrence is unlikely, or event is not expected to occur; but may occur during the life of the facility or operation.	10 ⁻⁴ to 10 ⁻²
Medium	Event may occur during the facility or operation lifetime	10 ⁻² to 10 ⁻¹
High	Event is likely to occur several times during the facility or operation lifetime.	> 10 ⁻¹

The probability of each event tree branch was estimated by examining pairs of events and estimating the probability of event pairs as shown in Table 6 Where more than two events make up an event tree branch the branch probability was estimated by examining pairs of events, treating a pair as a single event and reentering Table 6

Table 6 Probability estimates for combined events

	Incredible	Extremely Low	Low	Medium	High
Incredible	Incredible	Incredible	Incredible	Incredible	Incredible
Extremely low	Incredible	Incredible	Incredible	Extremely Low	Extremely Low
Low	Incredible	Incredible	Extremely Low	Low	Low
Medium	Incredible	Extremely Low	Low	Low	Medium
High	Incredible	Extremely Low	Low	Medium	High

The probability of a hazard scenario was taken as the probability of the most likely branch in the associated event tree. No attempt was made to sum probabilities over all branches as the trees contain relatively few branches. Summing over branches in a quantitative probability estimation scheme would affect the probability estimates by a factor of 3 to 5. Such changes are below the resolution of the qualitative scheme adopted here.

The probability estimates of this analysis are used in the updated SAR summary hazard tables and together with the estimated consequences form the basis for deciding risk acceptability.

5.0 References

Ingram 2000	"Safety Question Review for Building 801, Proof Testing of Contained Firing Facility," SQR No.: BdivS300-CY00-CFF-01, C. Ingram, Livermore National Laboratory, Livermore, CA (November 13, 2000)
LLNL 1997	Site 300 B-Division Firing Areas Safety Analysis Report, UCRL-AR-122036, Rev. 1, Lawrence Livermore National Laboratory, Livermore, CA (September 1997)
LLNL Current	Environmental Safety and Health Manual, UCRL-MA-133867, Lawrence Livermore National Laboratory, Livermore, CA (November 2000)
LLNL 2000a	Facility Safety Plan, B Division Site 300, S300.1, Change 2, Revision 1, Lawrence Livermore National Laboratory, Livermore, CA (October 1, 2000)
LLNL 2000b	"Operation of Three-Inch Gas Gun," Operational Safety Procedure No. 300.64, Lawrence Livermore National Laboratory, Livermore, CA (March, 2000)
LLNL 2000c	"Potential Scattering of Explosives by Shape Charges," Operational Safety Plan No. 300.66, Lawrence Livermore National Laboratory, Livermore, CA (July 1, 2000)
LLNL 2000d	"Use Of Propane Burning to Remove Unexpended Explosives Contaminant Residue from B Division Firing Tables," Operational Safety Plan No. 300.71, Lawrence Livermore National Laboratory, Livermore, CA (December 1, 2000)
LLNL,2000e	"Use of a 1550 nm cw Laser at B-Division Site 300 Firing Facilities, "Operational Safety Plan No. 851.12, Lawrence Livermore National Laboratory, Livermore, CA (August 1, 2000)
LLNL 2001	"Explosives Experiments at Elevated Temperatures; Post Test Handling," Operational Safety Plan No. 300.68, Lawrence Livermore National Laboratory, Livermore, CA (January 24, 2001)
Visoria 2001	"Description Contained Firing Facility," R. Visoria, A. Lee, L. Simmons, C. Ingram, Lawrence Livermore National Laboratory (January 5, 2001)

Appendix A

Detailed Hazard Tables

	Project:	Site 300 SAR				·			
	Location:	Firing Table, CFF	Firing Chamber, CF	F Gray Area					
	Condition:	HE transport							
icenario Io.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard
		-							Scenario
1	Mobilelift or	Fire on nearby	Hydraulic fluid	Observed by	Inspection of	HE detonation	Facility		В
	Forklift:	vehicle creates	leak with ignition		vehicle hydraulic	(personnel death			
	Batteries,		source, Hydrogen		and electrical	or injury)	Response		
	Hydraulic fluid	detonate HE	leak with ignition		systems before		Procedures,		
		when personnel	source	Activation (CFF	first use on a		Operational		
		present		gray area only)	given day		access controls		
	!			g,,,	J		limit number of	1	
						,	exposed		•
							personnel,		
							Separated		
							emergency exits		
						İ	in firing chamber		
							Q-D siting /	'	
							Maximum		
							explosives		
							weight, Sites		
	<u> </u>	·					Remote location,		
~							Confinement		
							system (CFF		-
							Only)	•	
							Only)		
					Periodic				
					inspection of				1
					vehicle batteries	A STATE OF THE STA	·		
					venicie batteries				
					Approved				1
					Approved explosives				
1					1 '				
					handling				
					equipment				
				1	Control of				
					ignition sources				
				1	Separation				
				1	distance				
					between			,	
					combustible				
1					materials and				
Firing Tal	ble, CFF Firing Ch	amber, CFF Greay	Area - HE Transpor	t ^l	explosives	. 1	1	1	Page 1 of

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Firing Chamber, CFF Gray Area HE transport								
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario	
					Hand held fire					
					suppression Evacuation to					
					approved cover if fire threatens					
					HE					
					Separated exits from CFF firing					
					chamber TV cameras and					
					atmosphere monitoring					
					systems to					
					support fire response					
					Time delay before entering					
					area with					
					unreacted HE Limited time of				-	
					HE exposure to hazards					

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF I HE transport	Firing Chamber, CF	F Gray Area					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
2	Seismic Event	Mechanical impact or friction sufficient to detonate or react HE when personnel present	Inadequate support	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Nearby equipment separated from HE and supported to prevent falling	HE detonation (personnel death or injury)	Facility Emergency Response Procedures, Operational access controls limit number of exposed personnel, Q-D siting / Maximum explosives weight, Sites Remote location, Confinement system (CFF Only)		A
					Design of test stands Transport container or other cushioning material protect from shock and friction during transport Limited time of HE exposure to hazards	S			

Detecting Event I eathers Controductions I arrange		Location:	_	Firing Chamber, CF	r Glay Alea			•		
Detecting Event Detecting (personnel death (personnel de		Condition:				1_	I	la at the state of	0	CAD
Sufficient to fire detonators or to directly initiate HE when personnel present with the structure as an electrical shield personnel present with the structure as an electrical shield personnel present with the structure as an electrical shield personnel present with the structure as an electrical shield personnel present with the structure as an electrical shield personnel, Heat detectors (CFF dray area only) warning the structure and the structure as an electrical shield personnel, Q-D siting / Maximum explosives area as soon as practical after lightning alert warning warning warning personnel death shorted until final shorted until final shorted until final shorted until final access controls limit number of exposed personnel, Q-D siting / Maximum explosives area as soon as practical after lightning alert warning warning warning the structure as an electrical shield personnel death shorted until final shorted		Hazard	Deviation	Possible Causes		t .			Comments	Hazard Scenario
Sufficient to fire detonators or to directly initiate HE when personnel present with the second personnel detectors (CFF gray area only) Sufficient to fire detonators or to directly initiate HE when personnel present with the second personnel present with the second personnel detectors (CFF gray area only) Sufficient to fire detonators or to dignthing warning warning on lightning alert with the sufficient personnel detectors (CFF gray area only) Sufficient to fire detonators or to dignthing warning on lightning warning of sufficient to fire detonators or injury) Personnel death shorted until final shorted until fin										
personnel, Q-D siting / Maximum explosives weight, Sites Remote location, Confinement system (CFF Only), Evacuation of explosives area as soon as practical after lightning alert High energy initiators used except as approved under specific OSP Evacuation to approved cover on lightning warning Detonator leads	3	Lightning	sufficient to fire detonators or to directly initiate HE when personnel	violation, Failure of lightning	Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF	disconnected and shorted until final	(personnel death	Emergency Response Procedures, Operational access controls limit number of	most likely not applicable to CFF, but credit is not taken for firing chamber structure as an	
System (CFF Only), Evacuation of explosives area as soon as practical after lightning alert High energy Initiators used except as approved under specific OSP Evacuation to approved cover on lightning warning Detonator leads								personnel, Q-D siting / Maximum explosives weight, Sites Remote location,		
High energy Initiators used except as approved under specific OSP Evacuation to approved cover on lightning warning Detonator leads								system (CFF Only), Evacuation of explosives area as soon as practical after		
Initiators used except as approved under specific OSP Evacuation to approved cover on lightning warning Detonator leads										
Evacuation to approved cover on lightning warning Detonator leads						Initiators used except as approved under				
Detonator leads						Evacuation to approved cover on lightning				
grounded until personnel under						Detonator leads / initiation circu grounded until	nit	•		

	Project:	Site 300 SAR							
	Location:	Firing Table, CFF I	Firing Chamber, CF	F Gray Area					
	Condition:	HE transport	-,	•	*				
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
•									
					Separated exits from CFF firing chamber Limited exposure time				
4	Mobilelift, Forklift or other lifting equipment: Mechanical Impact	Mechanical impact or friction sufficient to detonate or react HE when personnel present	Human Error, Failure of vehicle controls	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Approved explosives handling equipment	HE detonation (personnel death or injury)	Response Procedures, Operational access controls limit number of		A
•							exposed personnel, Q-D siting / Maximum	1	
							explosives weight, Sites Remote location, Confinement	,	
						1	system (CFF Only)		
					Inspection of crane and forklif				
					tires, steering, suspension and lift mechanisms				
					prior to first use in a given day.				
					Transportation containers or				
					other cushioning material				

	Project:	Site 300 SAR			**************************************				
	Location:	Firing Table, CFF I	Firing Chamber, CF	F Gray Area					
	Condition:	HE transport	J			•			
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
									Scenano
	i .				Specific OSP				
	İ		1		required for			,	
					handling of large				
					explosive				
					charges				
				~	Plans and				
				ļ	procedures for movement of				
	1				explosives				
					Training and				
					qualification of				
					explosives				
					handlers	•			
	HE dropped or	Mechanical	Human Error	Observed by	Training and	HE detonation	Facility		Α
•	slid	impact or friction		Personnel, Heat		(personnel death			
		sufficient to		detectors (CFF	explosives	or injury)	Response		
		detonate or		only), Sprinkler	handlers		Procedures,		
		react HE when		Activation (CFF			Operational		
		personnel		gray area only)			access controls		
		present					limit number of		
							exposed		
							personnel, Q-D		
					·	4.7	siting / Maximur	n	
							explosives		
							weight, Sites		
							Remote location	•	
							Confinement		
							system (CFF		
							Only)		
					Two person lift				
İ					of large explosiv	/e			
ĺ					charges				
i					1		1		j

	Project:	Site 300 SAR							
	Location:	Firing Table, CFF F	Firing Chamber, CFI	F Gray Area					
	Condition:	HE transport							
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features		Migitative Features	Comments	SAR Hazard Scenario
	! 				Use of approved work procedures				
					Specific OSP required for handling of large explosive charges				
	Shrapnel from tire blowout	Mechanical impact or friction sufficient to detonate or react HE when personnel present	Equipment failure	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Inspection of	HE detonation (personnel death or injury)	Facility Emergency Response Procedures, Operational access controls limit number of		A
							exposed personnel, Q-D siting / Maximum explosives weight, Sites Remote location		
							Confinement system (CFF Only)		
					Limited time of HE exposure to hazards				

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF I HE transport	Firing Chamber, CF	F Gray Area					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
7	Equipment Falling	Mechanical impact or friction sufficient to detonate or react HE when personnel present	Human Error, Inadequate support, Failure of vehicle controls	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Transport container or other cushioning material protects from shock and friction during transport	HE detonation (personnel death or injury)	Facility Emergency Response Procedures, Operational access controls limit number of exposed personnel, Q-D siting / Maximum explosives weight, Sites Remote location Confinement system (CFF		A
					Nearby equipment separated from HE and supported to prevent falling Limited exposur-	е	Only)		

	Project:	Site 300 SAR						•	
	Location:	Firing Table, CFF	Firing Chamber, CF	F Gray Area					
	Condition:	HE transport		•					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
								-	
8	Fire in or around firing table or CFF service building	Fire creates sufficient heat to detonate HE	Brush/grass fire (N/A CFF)	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF	Minimize amount of combustible materials.	HE detonation (personnel death or injury)	Response Procedures, Operational		В
				gray area only)			access controls limit number of exposed		
							personnel, Separated emergency exits in firing chamber		
							Q-D siting / Maximum explosives weight, Sites		
							Remote location		
					Control of ignition sources Hand held fire suppression Evacuation to			3	
					approved cover if fire threatens HE				
					Time delay before entering area with unreacted HE				
					Limited exposure	е			

	Project: Location:	Site 300 SAR Firing Table, CFF	Firing Chamber, CF	F Gray Area					
	Condition:	HE transport						T	
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
9	Inert or toxic gas systems	Inert or toxic gas leak into confined space	Equipment failure	Atmosphere Monitoring System, Observed by Personnel	Design of gas systems to contain toxic or inert gas	Personnel injury or death (poisoning, suffocation, lung damage).	Facility Emergency Response Procedures, Ventilation		P
				reisonnei		gamago).	systems in areas containing toxic gas, inert gas, or firing chamber ventilation ducting		
					Ventilation systems in areas containing toxic gas, inert gas, o firing chamber ventilation ducting	l			

	Project:	Site 300 SAR					·		
	Location:	Firing Table, CFF	Firing Chamber, Cl	FF Gray Area					
	Condition:	Shot setup							-
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
1	Mobilelift or Forklift: Batteries, Hydraulic fluid	Fire on nearby vehicle creates sufficient heat to detonate HE	Hydraulic fluid leak with ignition source, Hydrogen leak	Observed by Personnel, Heat detectors (CFF only), Sprinkler	and electrical systems before	HE detonation (personnel death or injury)	Response Procedures,		В
		when personnel present	with ignition source	Activation (CFF gray area only)	first use on a given day		Operational access controls limit number of exposed		
							personnel, Separated		·
							emergency exits in firing chamber, Q-D		
							siting / Maximum explosives		
							weight, Sites Remote location	•	
							Confinement system (CFF Only)		
					Periodic inspection of				
					vehicle batteries	s			
					Control of ignition sources				

	Project:	Site 300 SAR		!					
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area			:		
	Condition:	Shot setup						1	
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard
				'					Scenario
			•						
	,				1-			<u> </u>	
					Separation				
					distance				
		1 >			between				
					combustible				
					materials and				
\					explosives				
					Hand held fire				
					suppression				
				_	Evacuation to				
	-		-		approved cover				
					if fire threatens		·		
	1	,	*		HE				
					Separated exits				
					from CFF firing				
					chamber				
					TV cameras and	1			
,					atmosphere				
					monitoring ·				
					systems to				
					support fire				
					response				
				,	Time delay				
}		!			before entering			-	
					area with				
					unreacted HE				
					Limited time of				
					HE exposure to	· .	*.		
1					hazards		•		

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	Firing Chamber, C	 FF Gray Area 					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
2	Seismic Event	Mechanical impact or friction sufficient to detonate or react HE when personnel present	Inadequate support	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Design of test stands	HE detonation (personnel death or injury)	Facility Emergency Response Procedures, Operational access controls limit number of exposed personnel, Q-D siting / Maximum explosives weight, Sites Remote location Confinement system (CFF Only)	Assume HE secured on firing table during this condition. Other condition is covered under transport condition.	A
					Nearby equipment separated from HE and supported to prevent falling Limited time of HE exposure to				

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	 Firing Chamber, Cl 	 FF Gray Area 					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
3	Lightning	Electrical input sufficient to fire detonators or to directly initiate HE when personnel present	Procedure violation, Failure of lightning warning	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Detonators disconnected and shorted until final arming	HE detonation (personnel death or injury)	Response Procedures, Operational access controls limit number of exposed personnel,	most likely not applicable to CFF, but credit is not taken for firing chamber structure as	С
							Separated emergency exits in firing chamberQ-D siting / Maximum explosives	an electrical shield	
							weight, Sites Remote location, Confinement system (CFF Only), Evacuation of explosives area as soon as practical after lightning alert		

	Project:	Site 300 SAR							
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area					
	Condition:	Shot setup	1						
Scenario	Hazard	Deviation	Possible Causes	Methods of	Preventative	Possible	Mitigative	Comments	SAR
No.	Tiazaiu	Deviation	l ossibio oddsos	detecting event	1	Consequences	Features		Hazard
									Scenario
1					1				
	1				High energy				
•	1			<u> </u>	Initiators used				
		i 1		*	except as				
					approved under specific OSP				
					Detonator leads				
			1		/ initiation				
					circuit grounded				
ļ		,			until personnel				
				:	under cover				
				• •					
					F				
					Evacuation to approved cover				
			·		on lightning				
					warning		·		
					Separated exits				
		į.			from CFF firing				
					chamber				
					Limited time of				
					HE exposure to				
					hazards		*		

	Project:	Site 300 SAR							
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area					
	Condition:	Shot setup							
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
	,								
4	Electrical equipment	Fire on nearby electrical equipment creates sufficient heat to detonate HE	Equipment failure	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Periodic inspection of electrical equipment located near HE.	HE detonation (personnel death or injury)	Response Procedures, Operational access controls		В
							limit number of exposed personnel,		
			1				Separated emergency exits in firing		
							chamber, Q-D siting / Maximum		
							explosives weight, Sites Remote location		
							Confinement system (CFF		
					Hand held fire		Only)		
					suppression Use of approved work procedure				

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	Firing Chamber, C	FF Gray Area					
Scenario No.		Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
•									
					Prior review and approval of				
					portable electrical				
					equipment Installed				
					equipment rated for use in areas				s*************************************
			•		of explosives hazard				
					Separation distance				
					between combustible				
					materials and explosives				
					Separated exits from CFF firing				
					chamber TV cameras and	,			
					atmosphere monitoring				
	,				systems to support fire				
					response Time delay				
	·				before entering area with unreacted HE		•		

	Project: Location:	Site 300 SAR Firing Table, CFF	Firing Chamber, C	FF Gray Area					
	Condition:	Shot setup							
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
nagement de la contraction de					Limited time of HE exposure to hazards				
5	Solvents	Chemical fire creates sufficient heat to detonate HE	Human Error, Equipment failure	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF	Control of ignition sources	HE detonation (personnel death or injury)	Facility Emergency Response Procedures, Operational		В
				gray area only)			access controls limit number of exposed		
							personnel, Separated emergency exits in firing		
							chamber, Q-D siting / Maximum		
							explosives weight, Sites Remote location	1,	
							Confinement system (CFF Only)		
					Minimize amour of combustible materials.	nt			

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	 Firing Chamber, C	 FF Gray Area 	,				
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
					Separation distance between combustible materials and explosives Use of approved work procedures				
					Hand held fire suppression Evacuation to approved cover if fire threatens				
					Separated exits from CFF firing chamber TV cameras and atmosphere monitoring				
					systems to support fire response Time delay before entering area with unreacted HE				

F	Project:	Site 300 SAR							
L	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area					
(Condition:	Shot setup			1				0.45
1	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
					Limited time of HE exposure to hazards				
611	Portable Radios	RF output	Procedure	Observed by	Radio	HE detonation	Facility		С
-	. 5. 125.5 . 124.00	sufficient to	violation	Personnel, Heat	transmitters	(personnel death			
		trigger		detectors (CFF	controlled in	or injury)	Response		
Ì		detonator		only), Sprinkler	area		Procedures,	-	
1				Activation (CFF			Operational		
				gray area only)			access controls		
							limit number of		
							exposed		
ļ				1	* .		personnel,		
							Separated		
						• .	emergency exits		
							in firing		
							chamberQ-D		
					4.00		siting /		
							Maximum		
							explosives		
							weight, Sites		
							Remote location	•	
							Confinement		
							system (CFF		
							Only)		
				•			Confinement system (CFF		

	Project:	Site 300 SAR							
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area					
	Condition:	Shot setup		1					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
									-
-					Detonator leads / initiation circuit grounded until personnel under cover				
			·						
					High energy Initiators used except as approved under				
					specific OSP Detonators disconnected and shorted unti	ii			
					Limited time of HE exposure to hazards				

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	Firing Chamber, Cl	FF Gray Area					
Scenario No.		Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
7	Flash Devices, Diagnostic lasers	Personnel exposure to laser beam or intense light sufficient to cause injury	Inadequate muster, Equipment failure, Inadequate maintenance of beam filters, Beam scattering or reflection, Wiring error	Observed by Personnel	Compliance with ANSI Standard Z136.1	Personnel injury (eye damage and physical burns).	Facility Emergency Response Procedures, Operational access controls limit number of exposed personnel, Laser safety glasses		L
					Interlocked laser room shutter for pulsed laser	1 .			
					Control of dark flap key Capacitor bank interlocks Enclosed optica	1			
					paths for high intensity lasers Leak testing of high intensity laser paths				
					before connection to high intensity laser source		•		

	Project:	Site 300 SAR					1		1
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area					
	Condition:	Shot setup	1	1					
Scenario No.		Deviation	Possible Causes	Methods of	Preventative	Possible	Mitigative Features	Comments	SAR Hazard
NO.				detecting event	reatures	Consequences	reatures		Scenario
								·	
					Optical fiber end				
					caps when fibers				
	i				for high intensity				
					lasers are not				
	1				connected				
		·			Muster before				
		;			generation of				
		· .			intense laser				
					light				
					Light filters			·	
		· ·			Training and				
					qualification of				
		1			personnel				
	!				Paging				
					announcements before firing				
					Visual				
					observation of				
					firing area				
		1			Use of approved				
					work procedures				
					Signs and alarms	S			
	İ								

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup							
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
8	Flash Device Power Supplies	Electrical input sufficient to fire detonators or to directly initiate HE when personnel	Equipment failure	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Detonator leads / initiation circuit grounded until personnel under cover	HE detonation (personnel death or injury)	Response Procedures, Operational access controls		C
		present					limit number of exposed personnel, Separated emergency exits in firing		
							chamberQ-D siting / Maximum explosives weight, Sites Remote location		
					Detonator		Confinement system (CFF Only)		
·					cables separated from other energized cable				

,	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	 Firing Chamber, C 					Comments	SAR
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	Hazard Scenario
									-
					Detonators disconnected and shorted until final arming				
					Test stand electrically isolated from floor by rubber				
					mat Limited time of HE exposure to hazards	1			
					Use of approved work procedure				
					Electronic photographic flashes				
					evaluated for intrinsic safety before use and separation				
					distance from explosives maintained				

	Project:	Site 300 SAR					. *		
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area				,	
Scenario No.	Condition: Hazard	Shot setup Deviation	Possible Causes	Methods of detecting event	1	Possible Consequences	Mitigative Features	Comments	SAR Hazard
10.									Scenario
9	Exposed Conductors	Electrical input sufficient to fire detonators or to directly initiate HE when	Fire with hot- short	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF	Detonator cables separated from other energized cables	HE detonation (personnel death or injury)	Response Procedures, Operational		С
*.		personnel present		gray area only)			access controls limit number of exposed		-
							personnel, Separated emergency exits		
							in firing chamberQ-D siting /		
							Maximum explosives weight, Sites		
							Remote location Confinement system (CFF		
					Test stand		Only)		
					electrically isolated from floor by rubber				
					mat Hand held fire suppression				

1	ition: dition:	Firing Table, CFF Shot setup	Firing Chamber, Cl	FF Gray Area					
Scenario Haza		Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
					Limited time of HE exposure to hazards Noninitiating systems disconnected or connected through intrinsic safe boxes when personnel				

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup							040
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
10	ESD	Electrical input sufficient to fire detonators or to directly initiate HE when personnel	Electrostatic discharge triggers detonator	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Detonator leads / initiation circuit grounded until personnel under cover	HE detonation (personnel death or injury)	Facility Emergency Response Procedures, Operational access controls		C
		present		gray area erry			limit number of exposed personnel, Separated		
							emergency exits in firing chamberQ-D siting /		
							Maximum explosives weight, Sites Remote location Confinement		
							system (CFF Only)		
•					High energy Initiators used except as approved under specific OSP				

	Project:	Site 300 SAR				1			
	Location:	1	Firing Chamber, C	FF Grav Area					
	Condition:	Shot setup		 					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
					Detonators disconnected and shorted until				
					final arming				
					Test stand electrically isolated from floor by rubber				
			·		mat Tasks involving tools and other				
					spark sources completed before explosives				
					arrive. Limited time of				
					hazards Personnel				
					handling ESD sensitive explosives /				
					components wear clothing that does not				
					generate static electricity.				

	Project:	Site 300 SAR							
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area					
	Condition:	Shot setup							1
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
11	Chemical reactor with assembly materials	reaction on HE creates	Unanticipated chemical reaction,	Observed by Personnel, Heat detectors (CFF	in contact with HE evaluated for	HE detonation (personnel death or injury), or	Response		D
		sufficient heat input to: cause detonation, sensitize HE	Procedure violation	only)	compatibility	Toxic gas release	Procedures, Operational access controls limit number of		
		such that detonation caused by normal					exposed personnel, Separated emergency exits		
		acceptable energy source, or release toxic					in firing chamberQ-D siting /		
		gas.					Maximum explosives weight, Sites Remote location Confinement	•	
							system (CFF Only)		
					Training and qualification of explosives handlers				
					Use of approved work procedure	l .	•		

•	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	 Firing Chamber, C 	 FF Gray Area 					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
12	Preconditioning heaters, Diagnostic lasers	Sufficient heat input to cause detonation or to catalyze detonation caused by other energy sources	Equipment	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only), HE temperature monitoring	Redundant temperature control systems maintain temperature below critical temperature when chamber is manned, except as allowed by specific OSP.	i	Facility Emergency Response Procedures, Operational access controls limit number of exposed personnel, Separated emergency exits in firing chamberQ-D siting / Maximum explosives weight, Sites Remote location Confinement system (CFF Only)		E
					Use of approved heating equipment	1			

	Project: Location:		Firing Chamber, C	FF Gray Area					
Scenario No.	Condition:	Shot setup Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
									Scenario
					Grounding of high energy heater leads when personnel present Use of approved				
					work procedures Limits on allowed laser				
					intensity when personnel present Temperature monitoring				
					Muster before generation of intense laser light Interlocked laser				
					room shutter for pulsed laser Control of dark	1			1
					flap key				

	Project: Location:	1	Firing Chamber, Cl	FF Gray Area					
	Condition:	Shot setup							
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
13	Test launcher or gun	Premature firing of launcher or gun	Wiring error, Equipment failure, Exposure of launcher to hazards similar to those analyzed for HE., Inadequate muster, Use of incorrect test equipment	only), Sprinkler Activation (CFF gray area only)	Protection from unplanned initiation inputs similar HE detonation hazards.	HE detonation (personnel death or injury)	Facility Emergency Response Procedures, Operational access controls limit number of exposed personnel, Q-D siting / Maximum explosives weight, Sites Remote location, Confinement system (CFF Only)		F

	Project:	Site 300 SAR							,
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area					
	Condition:	Shot setup		·					
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
1 4	HE with attached	Planned source of electrical or	Equipment failure, Use of	Observed by Personnel, Heat	Key interlocked firing and	HE detonation (personnel death			G
	detonators	laser input causes	incorrect test equipment,	detectors (CFF only), Sprinkler	charging circuits	or injury)	Response Procedures,		
	-	detonators to	Wiring error,	Activation (CFF			Operational		
		fire while	Inadequate	gray area only)			access controls		
		personnel in chamber	muster	_			limit number of exposed		
		Cilamber					personnel, Q-D		
						,	siting /		
							Maximum		
							explosives weight, Sites		
							Remote location		*
							Confinement		
							system (CFF	-	
							Only)		
		i i i ·			High energy				
					Initiators used				
					except as approved under				
	,				specific OSP				
					Use of approved	1			
	İ				test equipment				
					for initiating				
j	1	i I	1	1	circuits.		I,	1	l

	Project:	Site 300 SAR				1			1
	Location:	1	Firing Chamber, C	FF Grav Area					
	Condition:	Shot setup	-	Gitty Alea					
Scenario	Hazard	Deviation	Possible Causes	Methods of		15 "			
No.		Deviation	Possible Causes	detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
									Scenario
					Detonators				
					disconnected			ļ	
					and shorted until				
					final arming				
					Run / safe boxes				
					Interlocks				
					Beam blocks on				
					laser fibers				
	İ	i ,			connected to				
	1				detonators when				,
		!			personnel are				
	!				present				
	!	1							
	i				Use of approved				
					work procedures				
				1	Training and				
					qualification of				
					explosives				
	r				handlers				
					Paging				
									1
					announcements				
					before firing				
					Muster before firing				
	•		1	1	pining	1	1	1	1

	Project:	Site 300 SAR		i		i	!		
	Location:	Firing Table, C	FF Firing Chamber, C	FF Gray Area	:		:		
	Condition:	Shot setup		į	1				
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard
								•	Scenario
	•			*	! !				
			:		Detonator leads / initiation		i	:	
	:				circuit grounded until personnel			· '	
					under cover		!	! :	
			1 - 6		Installed equipment rated	1			
					for use in areas		•	!	
					of explosives hazard		:		
			1	•	Visual observation of	1	!		
	ı				firing area				

	Project:	Site 300 SAR	i						
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area		1	•	•	
	Condition:	Shot setup					· .		.
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
	:			! ! !	1 1 1		1 	•	
15	Test launcher or gun	Premature firing of launcher or gun	Equipment failure, Use of incorrect test equipment, Wiring error, Inadequate muster, Exposure of launcher to hazards similar to those analyzed for HE.	Observed by Personnel, Heat detectors (CFF only), Sprinkler Activation (CFF gray area only)	Control of gun cart key	Personnel death or injury from impact	Facility Emergency Response Procedures, Operational access controls limit number of exposed personnel, Q-D siting / Maximum explosives weight, Sites Remote location, Confinement system (CFF		J
					Launcher not loaded until just before firing Detonator leads / initiation circuit grounded until personnel under cover		!Only)		

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	Firing Chamber, C		:				i
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
									1 1 1 1 1
		-		:	High energy Initiators used	1			
					except as approved under specific OSP Run / safe boxes	3			
					Key interlocked firing and charging circuits				
					Use of approved work procedures			* (
					Training and qualification of explosives handlers				
					Muster before firing Paging announcements				
					before firing Shielding and sandbags Visual				
					observation of firing area		1	1	

	Project:	Site 300 SAR	!						
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area	1				
	Condition:	Shot setup		i		1			<u> </u>
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
			:				: :		! ! !
					Use of approved test equipment for initiating circuits.				
1 (3 X-ray machines & linear accelerators	Personnel radiation exposure	Failure of X-ray machine / linear accelerator	Observed by Personnel, Dosimetry	Interlocks	Personnel injury or death (radiation	Operational access controls limit number of		K
,	accelerators	exposure	control and	Dosinietry	1 1 2	exposure)	exposed		
		allowable	interlock	1 2		1	personnel, Facility	1	
		occupational dose	systems, Inadequate				Emergency		
			muster				Response Procedures	•	
					Paging		Frocedures	,	* * *
					announcements before firing	! !			
					Muster before				
	•			· ·	firing Run / safe boxes	s'			1
					Use of approved work procedures				
					Visual	i i	• •	· 	!
					observation of firing area				i i
					Training and qualification of				
			<u> </u>		personnel		<u>i</u>		

	Project:	Site 300 SAR		1		<u> </u>			
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area	:	· •			
	Condition:	Shot setup	· .						i
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
			5-1		I Daving of and	Possessed in items	!	1 1	P
1 /	Inert or toxic gas systems	Inert or toxic gas leak into	Equipment failure	Atmosphere Monitoring	Design of gas systems to	Personnel injury or death	Facility Emergency		
-	3	confined space		System,	contain toxic or	(poisoning,	Response	1	
			1	Observed by	inert gas	suffocation, lung		•	İ
			1	Personnel	1	damage).	Ventilation systems in areas	-	1
				‡		1	containing toxic	i	;
!					1		gas, inert gas, o	r!	
				ţ.		1	firing chamber	• · · · · · · · · · · · · · · · · · · ·	
	-				•	,	ventilation	•	:
			•				ducting	*	
	·				•		1		
					Ventilation			•	
			1		systems in areas			i	į
					containing toxic				
					gas, inert gas, of firing chamber	r:	•	1	
	•				ventilation				
					ducting				
					-			- 0 - 0 - 0	
			•				i i		i

	Project:	Site 300 SAR	:						
	Location:	Firing Table, CFF	Firing Chamber, C	FF Gray Area			1		i
	Condition:	Shot setup							į
Scenario Io.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
,	•						1	:	
1 8	HE accumulation in systems	Mechanical impact or friction	Procedure violation, Equipment	Observed by Personnel	Redundant filters or traps in vacuum lines	Personnel injury or illness	Facility Emergency Response		R
		sufficient to	failure		that provide a	† •	Procedures		
		detonate or	•		path between	•		1	
	-	react HE when	f	4	bare HE and	:		•	
		personnel			evacuated	•			
		present			volumes Washdown				į .
					system designed			•	
					to safely pump				
				•	fluids containing		• 1		i
			:		HE	1			
							,		i i
				. *	Wash down			1	!
			•	:	collected and			•	
					disposed of				· ;
			:		separately if	1			
			: :		unreacted	!			,
		•			material is	1		:	
			i		detected	•		!	:
				1	Sampling of	r E	•		
					washdown		:		1
			:		system filters		1		

	Project: Location: Condition:	Site 300 SAR Firing Table, CFI Shot setup	Firing Chamber, C	FF Gray Area	•	:			
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
			· ·	•		: : : : :			
					Washdown system filters disposed of as		÷		
					HE if HE concentration exceeds predetermined limit				
					Periodic inspection of potential HE				
	• .				collection points in ventilation, vacuum, and				
					washdown systems.				

Scenario Hazard No. Possible Causes Methods of detecting event Preventative Possible Mitigative Comments SAF		Project: Location: Condition:	Site 300 SAR Firing Table, CFF Shot setup	Firing Chamber, C	; FF Gray Area					! !
cutters impact or failure, Wiring friction error, sufficient to Inadequate detonate or react HE when personnel present exposed Training and qualification of explosives handlers Use of approved work procedures Limited exposure time Visual Cutters	Scenario No.	Hazard		Possible Causes	A Company of the Comp	•			Comments	SAR Hazard Scenario
detonate or react HE when personnel personnel present	1 9		impact or friction	failure, Wiring error,	•	/ grounding	(personnel death	Emergency Response	: :	S
personnel, Confinement system (CFF Only), Q-D siting / Maximum explosives weight, Sites Remote location Training and qualification of explosives handlers Use of approved work procedures Limited exposure time Visual			detonate or react HE when					Operational access controls limit number of		
/ Maximum explosives weight, Sites Remote location Training and qualification of explosives handlers Use of approved work procedures Limited exposure time Visual			present					personnel, Confinement		
Training and qualification of explosives handlers Use of approved work procedures Limited exposure time Visual				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		: : :		/ Maximum explosives	l : : :	
qualification of explosives handlers Use of approved work procedures Limited exposure time Visual						Training and				
work procedures Limited exposure time Visual						qualification of explosives handlers				
exposure time Visual						work procedures			1 d	
observation of						exposure time				

	Project:	Site 300 SAR				· ·		T-21, 2 1, 4 1, 4 1, 5 2	
	Location:	Firing Table, CF	F Firing Chamber, C	FF Gray Area				•	
	Condition:	Shot setup	:	<u>:</u>		1	·		
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard
110.				i		!		1	Scenario
						İ			į.
				•		i	1	1	
				4	1	1		1	<u> </u>
j		•	!	1	Muster before		:	<u>.</u>	
	•				firing		•		
0.4	0 Highly toxic	Inert or toxic	Container struck	Observed by	Container design	Personnal injury	Sites Remote	Not	U
2	materials	gas leak	or dropped,	Personnel,	Container design	or death	location,	applicable to	
	contained in	gas leak	Corrosion of	Monitoring	1	(poisoning,	Operational	CFF	
	experiments		container	equipment when	!	suffocation, lung	•		İ
			materials,	odor threshold is	·	damage).,	limit number of		
			Container	below exposure	1 - 1	Personnel injury	exposed	:	
			opened to	limits		(eye damage	personnel,		
			atmosphere due	:		and physical	Facility		.'
	·		to human error	•		burns).	Emergency		
							Response		1
				* 1			Procedures		
					Compatibility		1		
					review of				:
			*	• *	container			:	
	•		1 * *		materials		•		4
				i e	Leak testing of		1		1
		•	i ·		container prior	(C)		!	
					to filling				
) •	1	Onsite				:
					transportation	1		1	ì
					procedures for	1		•	i 1
					highly toxic	•			
L		ä		· · · · · · · · · · · · · · · · · · ·	materials	<u> </u>	<u>:</u>	i	

	Project:	Site 300 SAR		:	 -		•		
	Location:	Firing Table, CFF	Firing Chamber				.		
	Condition:	Post shot			,	!			
Scenario	Hazard	Deviation	Possible Causes	Methods of	Preventative	Possible	Mitigative	Comments	SAR
۷o.				Detecting Event	Features	Consequences	Features	1	Hazard
	•			4		i !	1.		Scenario
			111	100	A	 Danasana	Onerstical	<u>!</u>	181
1	Toxic explosion	Firing chamber is		Atmosphere	Atmosphere	Personnel injury or death	Operational access controls	į	N
	by products,	•	system airflow	Monitoring	monitoring	I.	limit number of		
	Explosion	. •	less than design		•	(poisoning, suffocation, lung		1	İ
	creates oxygen	personnel entry	•	Observed by Personnel,		damage).	exposed personnel,		İ
	diffident		1	Chamber		damage).	Facility		
	atmosphere(CFF			pressure		1	Emergency		
	Only)		i.	monitoring, Hand			Response		
			•	held atmosphere		•	Procedures,		
				monitoring	1	•	Portable gas		
				monitoring		1	monitoring used	-	
		$\mathbf{r}_{i} = (\mathbf{r}_{i}, \mathbf{r}_{i}, \mathbf{r}_{i}) \in \mathbb{R}^{n}$				1	on entry	1	
				•	Firing chamber	1		1 .	
			4		pressure				į
			1		monitoring				
			:	i .	Firing chamber			1	
				i !	purge and			1	
				į	ventilation	1			
			•	1	Confined space		1	÷	į
			1	1	entry	!	1		
	•		•		procedures		*		
				1	Use of			1	
				i	appropriate		į	i	
					personnel			1	
	•	V	•	•	protective		1		`
				· ·	equipment				
	•				Use of approved				
			1,		work procedures	S		į	

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Post shot	Firing Chamber		:				
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
2	Unreacted HE after test	as a result of normal handling	recognize explosive hazard posed by test residue,	Observed by Personnel, Heat detectors (CFF only)	assessment of firing chamber using CCTV or robot-mounted	HE detonation (personnel death or injury)	Response Procedures, Operational		Н
			Inadequate cleanup procedure	: • • .	TV		access controls limit number of exposed personnel, Debris shield on		
							burner vehicles (not CFF), Sites Remote location Confinement system (CFF		
					Recovery of unexpended explosives under		Only)		
					control of OSP or explosives expert				
					Detonation in place of unexpended explosives considered unsafe to handle				

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Firing Chan Post shot			! ! !		1	
Scenario No.	Hazard	Deviation Possible Co	auses Methods of Detecting Event		Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
				Training and qualification of explosives handlers Time delay before entering area with	<u>:</u>			
			•	unreacted HE Explosives qualified vacuum cleaner				
	•			Burn-off of residual HE that is not amenable				
				to hand collection (not CFF) Use of static				
				free clothing and bags Use of soft soled shoes Washdown of	:			
		+1 ³ - :	·	residue (CFF				;

	Project: Location: Condition:	Site 300 SAR Firing Table, CFF Post shot	Firing Chamber						i
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Mitigative Features	Comments	SAR Hazard Scenario
3	Fire in or around firing table or CFF service building	Brush/grass fire (N/A CFF)	Detonation of explosives on- firing table ignites grass	Observed by Personnel	Clear zone around bunker firing table	or death (radiation	Fire hydrants and extinguishers, Fire breaks, Fire department, Evacuation	Not applicable to CFF	M
					Controlled burns		•		:
		•			Restricted shot time (not firing on high wind days) Fire breaks		• • • • • • • • • • • • • • • • • • •		
			: :		Fragment analysis Fire department		• • 1		

	Project:	Site 300 SAR							
	Location:	Vent duct areas,	CFF Gray Area						
	Condition:	Post shot							
Scenario	Hazard	Deviation	Possible Causes	Methods of	Preventative	Possible	Migitative	Comments	SAR
No.			: !	Detecting Event	Features	Consequences	Features		Hazard Scenario
					: ! !	i i			
	:Toxic explosion	Facility areas in	Firing chamber	Hand-held	Structural design	Personnel injury	Facility		N
	by products,	which firing	not isolated	atmosphere	of isolation	or death	Emergency		
	Explosion	chamber purge	during shot,	monitoring,	valves and	(poisoning,	Response	1	
	creates oxygen	and vent ducts	Leakage past	Observed by	penetrations	suffocation, lung	Procedures,		
	diffident	are routed	firing chamber	Personnel	1	damage).	Portable gas	r.	
	atmosphere	contain toxic or	doors	•	i		monitoring used	1	1
	•	oxygen diffident				j	on entry,		
		atmosphere		•			Ventilation		
					ř.		systems in areas		
						•	containing toxic		ļ
				:			gas, inert gas, or		
					ŧ	1	firing chamber	1	
							ventilation		1
			4 1		:	1	ducting,		
							Operational	1	
					•	1	access controls		
			d.	i	1		limit number of		
				1			exposed	i :	
						!	personnel		
			f		1		1		
			1	*	:	į			
			1		Firing chamber		:		
			$A_{ij} = A$		vent ducts not		1	!	
		•	* *		routed through		1		
			1		areas inhabited	!			
			- :		during shot	· · · · · · · · · · · · · · · · · · ·			ļ
				i	Isolation valve		1	1	
				ř	position	1			
			:		indication	*	5 ₁		
					Firing chamber	d	4 1		
					pressure	•		-	
					monitoring		1		1

	Project: Location: Condition:	Site 300 SAR Vent duct areas, Post shot	CFF Gray Area						
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
						!			
					Control over quantity of explosives in	1	:		
				: 	tests Muster before firing		i •	;	
					Structural design of bunkers and CFF firing		:		
					chamber Use of approved work procedures		1		

	Project: Location: Condition:	Site 300 SAR CFF Diagnostic Ed Post shot	quipment Room						
Scenario No.	Hazard			Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
			· · · · · · · · · · · · · · · · · · ·		1			!	
1	Toxic explosion by products, Explosion creates oxygen diffident atmosphere	fail to provide	•	Atmosphere Monitoring System, Observed by Personnel	Penetration design	Personnel injury or death (poisoning, suffocation, lung damage).	Facility Emergency Response Procedures, Portable gas	Would require massive failures of two sets of penetrations	N
				11 1. 1.			monitoring used on entry, Ventilation		
			1				systems in areas		
				· · · · · · · · · · · · · · · · · · ·		! !	gas, inert gas, or firing chamber ventilation		
				• • • • • • • • • • • • • • • • • • •			ducting, Operational		
				:			access controls limit number of exposed		
			1	i i			personnel		
·					Periodic inspection of penetrations				
				1	Double barrier between firing				
				!	chamber and occupied areas.				

	Project:	Site 300 SAR							
	Location:	CFF Diagnostic Ed	quipment Room						
	Condition:	Post shot							
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard
				I	•	1	i I	!	Scenario
			•	:	*	1		•	
				•		1	i		
		·				1	1	1	<u> </u>
	2 Blast effects and		Failure to	Observed by	Structural design	Personnel injury	Facility	:	T
	shrapnel from	•		Personnel	of bunkers and	1	Emergency		
	shot	effects or	penetrations or		CFF firing		Response		
		shrapnel as a	doors, Structural	1	chamber		Procedures,		
		result of planned	failure of bunker			1	Operational		
		firing	or CFF firing		1		access controls	1	ļ
			chamber, Failure	•	1	ř	limit number of		I .
		•	of CFF door				exposed	1	-1
			closing and			1	personnel, Q-D	1	į
		•	pinning		Ī	1	siting / Maximum	i :	
			mechanisms,				explosives weigh	t	i
			Error in size of		. 1				
	•		explosive, Error			•		1	!
			in locating	•					į.
			explosives	:			i		
					4	i ·	•		
				·					
					Double structura	H A	•		i .
					barriers between				
					CFF firing				
i					chamber and	!		•	
			•		diagnostic area			9	
						1			
	•								
					Layout of CFF	A Company	:		
			•		support area			1	. !
				•	shields occupied		• • • • • • • • • • • • • • • • • • •	1	1
					areas from blast		i .	1	!
			i b		effects in the	ļ		į	
			• • • • • • • • • • • • • • • • • • •			•	to the second of	İ	i
			•	i	event of door		1		ļ }
i			;	t	failure	1	i	1	F

	Project: Location: Condition:	Site 300 SAR CFF Diagnostic Post shot	Equipment Room						
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard
			4						Scenario
ı									
			į		·		, , , , , , , , , , , , , , , , , , ,	i i	1
					CFF firing	!			į
				,	chamber	1			1
					equipment door			1 	
					and door pin	· · · · · · · · · · · · · · · · · · ·			4
					indication				
					Training and	1		•	
					qualification of				
					explosives				1
					handlers			•	:
			•		Use of approved		•		-
					work procedures	S ¦			1
					011	•			: /
					Control over		:		i
					quantity of		•		:
					explosives in		:		
				±	tests	1			
			1		Localized	•	1		i .
					shielding	4 -	•	ì	1 .
			i	1	Experiment		:		. !
1			1	•	design review	i		1	4
			!		Pre-designated	!	• [•	
				•	test positions			1	
				• . •	Accidental	:			
		•	1		detonation	1			
				:	hazard zone		1		:

	Project:	Site 300 SAR							
	Location:	~	Room Penetration A	rea, Camera Roon	n				
	Condition:	Continuous				·			
Scenario No.	Hazard	Deviation	1	Methods of Detecting Event		Possible Consequences	Migitative Features	Comments	SAR Hazard
			:	•	i				Scenario
				ı			į	,	:
			1		:				
1	Inert or toxic gas	Inert or toxic gas	Equipment failure	Atmosphere	Design of gas	Personnel injury	Facility		iP
	systems	leak into		Monitoring	systems to	or death	Emergency		
		confined space	i	System,	contain toxic or	(poisoning,	Response	:	
				Observed by	inert gas	suffocation, lung	Procedures,		i
				Personnel	1	damage).	Ventilation		1
			· .	1			systems in areas	1	!
				•		İ	containing toxic	•	
		•	:		1		gas, inert gas, or firing chamber		
						;	ventilation	•	
					1		ducting		1
			1	1			duoting	i	
			1	i			1		
			i	1	Ventilation				
				1	systems in areas	·			1
					containing toxic				
					gas, inert gas, or				
			i		firing chamber ventilation				
			•	į	ducting				
			!		ducting		!		
							1		!
			•	1	Use of		i		
					appropriate	1	1	i I	
-				i :	personnel		!		
			:	1	protective				
				1	equipment	•		;	
					Confined space				
					entry procedures	3		ì	

	Project: Location:	•	s Room Penetration	Area, Camera Roon	n				-
Scenario No.	Condition: Hazard	Continuous Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
					Atmosphere monitoring			 	

	Project:	Site 300 SAR		the state of the	:	!			į
	Location:	Bunker / CFF co	ontrol room	:	· •	1 5	:		
	Condition:	Shot	1			1		i	
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event		Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
. 1	X-ray machines & linear	Personnel radiation	Shot	Observed by Personnel,	Shielding	Personnel injury or death	Operational access controls	<u>i</u>	K
	accelerators	exposure exceeds allowable		Radiation monitors,		(radiation exposure)	limit number of exposed personnel,		
		occupational dose					Facility Emergency Response		
							Procedures, Radiation monitors		
			: :		Radiation monitors Use of approved				
	•				work procedures	1			
					Training and qualification of personnel				

	Project:	Site 300 SAR		ı	1				
	Location:	Bunker / CFF cor	ntrol room		•	1	1		
	Condition:	Shot	i	:		i i		!	
Scenario	Hazard	Deviation	Possible Causes	:Methods of	Preventative	Possible	Migitative	Comments	SAR
No.			Î 	detecting event	Features	Consequences	Features		Hazard
			!			· .			Scenario
				<u>;</u>					
			'		1			:	
				:				i.	
2	Blast effects and		Failure to	Observed by	Structural design	Personnel injury	Facility		T
	shrapnel from	exposed to blast		Personnel	of bunkers and	i ·	Emergency	i	
	shot	effects or	penetrations or		CFF firing		Response		!
		shrapnel as a	doors, Structural	•	chamber	!	Procedures,	1	1 .
			failure of bunker	· '			Operational	ì	
		firing	or CFF firing	1			access controls	i .	•
			chamber, Failure			1	limit number of	•	
			of CFF door	4			exposed	1	
	•		closing and		1		personnel, Q-D	!	
	•		pinning	•			siting /		
			mechanisms,			:	Maximum		
			Error in size of explosive, Error		1		explosives		
			in locating	· ·	1	i	weight	ř.	
		,	explosives					1. 1	
			explosives					1	
							1	!	
		•			Separation	1		ĺ	
			!	1	distance	1			
				1	between CFF		· · · · · · · · · · · · · · · · · · ·	!	
	-1		!		firing chamber	$\frac{1}{2}$			
			ř		and control				1
			•	4.	room			:	!
					Training and	1	i ;	1	
			•		qualification of	:	t.	1	1
			•		explosives	1	•		i ·
				•	handlers	-	İ	1	

	Project:	Site 300 SAR	9	•	1	1	i i		i
	Location:	Bunker / CFF c	ontrol room	İ			i	:	
	Condition:	Shot	!		1		•		
Scenario No.	Hazard	Deviation	Possible Causes	Methods of detecting event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard
			:		!	t 1	1		Scenario
				*			1		
			· ·						
				1	Use of approved	<u> </u>			
				1	work procedures			;	1
			•	i	Work procedures	1			
ı			4	•	Control over	1	:	4 · · · · · · · · · · · · · · · · · · ·	i
			:	1	quantity of	1		:	· 1
					explosives in	1	1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	į ·	
					tests		*		
					Localized	1			
			t	!	shielding				
					Experiment	i e		0	
					design review			F	
					Pre-designated				
			;		test positions			!	1
				•	Accidental				
					detonation				
}			1	1	hazard zone		1	İ	1

	Project:	Site 300 SAR	:	:	1				
	Location:	Camera Room	!			i .	 	;· !	
	Condition:	Post shot	! •	!	b	<u> </u>		1	
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
1	Toxic explosion by products, Explosion creates oxygen diffident atmosphere	Personnel exposed to toxic gas in area due to camera or cable penetrations failure.	Failure of or leakage past penetrations	Atmosphere Monitoring System, Observed by Personnel, Chamber pressure	Penetration design	Personnel injury or death (poisoning, suffocation, lung damage).	Facility Emergency Response Procedures, Ventilation systems in areas containing toxic		N
				monitoring			gas, inert gas, or firing chamber ventilation ducting, Camera		
	ı.		1		· :	: :	exhaust systems		
				i	:				
					Muster before firing Periodic inspection of penetrations				
					Atmosphere monitoring Venting of camera room on overpressure Double lenses in camera	1			

	Project:	Site 300 SAR						:	ļ
	Location:	Camera Room				<u>.</u>	1 1		
	Condition:	Post shot	i i					i	!
Scenario	Hazard	Deviation	Possible Causes	· ·	Preventative	Possible	, ,	Comments	SAR
No.		<u>'</u> .		Detecting Event	Features	Consequences	Features		Hazard Scenario
					i			· · ·	
					Double barrier between firing chamber and				
					occupied areas. Confined space entry procedures				
	2 Beryllium	Beryllium	Equipment	Observed by	Camera rotors	Personnel injury	Facility	<u>:</u>	Q
•		scattered or	failure	Personnel,	designed for	or illness	Emergency		
		vaporized by	!	Monitoring	operational		Response		
		camera failure		equipment when odor threshold is		· 1	Procedures, Ventilation		
			· · ·	below exposure	:		systems in areas		
		•	* * * * * * * * * * * * * * * * * * * *	limitsAudio			containing toxic		
				monitoring		•	gas, inert gas, or	•	
			:	(B851 only)	1 · · · · · · · · · · · · · · · · · · ·	1	firing chamber ventilation		
			•	•			ducting, Camera		
		ţ		•	•		exhaust systems		
							. [
						†			
	r	•			Beryllium	i		; }	1
					contained by	!	i ·		
				1	camera case	•	i :		
				<u>.</u>	Muster before firing			· · · · · · · · · · · · · · · · · · ·	

	Project:	Site 300 SAR				: !			
	Location:	Camera Room		· • •	:	ļ		:	
	Condition:	Post shot	· •		1	:	:		
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event		Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
				í	:	i		1	
3	Blast effects and	Personnel	Error in locating	Observed by	Run / safe boxes	Personnel injury	Facility		0
•	shrapnel from		explosives, Error		:	or illness	Emergency	!	
	shot	effects or	in size of	1	•		Response		İ
	•	shrapnel as a	explosive, Failure	1	1	! .	Procedures,	1	•
	4	result of planned					Facility shape		
		firing	secure			1	shields camera	1	
		· · · • -	penetrations or	Tr.	1		penetrations	()	
			doors,	1	•	•	from fragments	;	1
			Inadequate	• •	•	k	and reduces		1
			muster	<u> </u>		1	overpressure,		
						4	Inhabited areas	:	
			4				protected from		i
							camera room by		1
						1	walls and, in CFF		1
							by distance,	İ	
					•	•	Camera room	1	
							venting,		
	•				•		confinement,	,	
				4.1			and design for		i
			* · · · · · · · · · · · · · · · · · · ·		1 1 1) (overpressure	!	
							(CFF only)		
				*	?	;	(Cir Ciny)	4	
	•		!		Interlocks	:		•	
						, 1	1		
			1		Control of safety	/		1	
					/ grounding		: 1		1
					panel key				
			•					1	
		•			Double lenses in	1 !	: .		i . ·
	4 4				camera			i i	1
1				•	penetrations	i		F	İ

	Project: Location: Condition:	Site 300 SAR Camera Room Post shot			:				
Scenario No.	Hazard	Deviation	Possible Causes	Methods of Detecting Event	Preventative Features	Possible Consequences	Migitative Features	Comments	SAR Hazard Scenario
						!	1		
					Structural design of isolation valves and penetrations				
					Training and qualification of explosives				
					handlers Paging announcements before firing				
			1		Muster before firing Control over				
					quantity of explosives in tests Experiment				
					design review Pre-designated test positions				

Appendix B

Summary Event Trees

Fig B.1 – SAR Scenario A -- Unplanned detonation on bunker firing table, in CFF firing chamber, or in CFF gray area with personnel present: Test charges are struck or dropped, causing detonation.

HE TEST CHARGES			PADDING TO		En	d State
ARE STRUCK OR DROPPED	OBJECT STRUCK	IMPACT ENERGY	PREVENT DETONATION	No.	Annual Probability	Description
		IMPACT NOT SUFFICIENT TO CAUSE DETONATION		1		NO DETONATION
1	HITS FLOOR		PADDING PREVENTS DETONATION	2		NO DETONATION
HE TEST CHARGES ARE	high	IMPACT SUFFICIENT TO CAUSE DETONATION low	PADDING INSUFFICIENT TO PREVENT DETONATION	3	Extremely Unlikely	HE CHARGE DROPS ONTO FLOOR, PADDING INSUFFICIENT, RESULTING IN DETONATION
STRUCK OR DROPPED medium		IMPACT NOT SUFFICIENT TO CAUSE DETONATION	low	4		NO DETONATION
		IMPACT SUFFICIENT TO CAUSE DETONATION low		5	Extremely Unlikely	HE CHARGE STRIKES OBJECT WITH SUFFICIENT ENERGY TO CAUSE DETONATION
			·			

Fig B.2 – SAR Scenario B. Unplanned detonation caused by Fire on bunker firing table, in CFF firing chamber, or in CFF gray area with personnel present.

Γ		EXTINGUISHMENT	SUFFICIENT HEAT	EVACUATION		En	d State
	FIRE NEAR TABLE	BEFORE HE INVOLVEMENT	TO CAUSE DETONATION	BERFORE DETONATION	No.	Annual Probability	Description
		EXTINGUISHED BEFORE HE INVOLVEMENT			1		NO DETONATION
	FIRE NEAR TABLE medium		INSUFFICIENT HEAT TO DETONATE HE		2		NO DETONATION
		EXTINGUISHMENT FAILS – FIRE INVOLVES HE medium		PERSONNEL EVACUATE	3	Low	DETONATION; PERSONNEL UNDER COVER
			SUFFICIENT HEAT TO DETONATE HE medium	PERSONNEL DO NOT EVACUATE IN TIME low	4	Extremely Unlikely	FIRE NEAR TABLE CAUSES HE DETONATION. PERSONNEL DO NOT EVACUATE, RESULTING IN INJURIES/DEATH

Fig B.3 – **SAR Scenario C1**. Unplanned detonation on bunker firing table, in CFF firing chamber, or in CFF gray area with personnel present: Electrical input from unplanned source. Detonator sensitive to ESD.

Ī	HE PRESENT WITH		DETONATORS	ESD SUFFICIENT TO		En	d State
	DETONATORS SENSITIVE TO ESD HAZARD	E ESD GENERATED GROUNDED OR SHORTED ESD SUFFICIENT TO FIRE DETONATORS		No.	Annual Probability	Description	
	· ·	ESD not generated			1		NO DETONATION
	He present with Detonators sensitive To ESD hazard high		Detonators grounded or short	ed	2		NO DETONATION
		ESD Generated medium	<u> </u>	ESD not sufficient to fire			·
			Detonators not grounded or shorted	detonators ESD sufficient to fire	3	Extremely	NO DETONATION DETONATION
				detonators medium	4	Unlikely	INJURIES/ DEATHS

Fig B.4 – SAR Scenario C2. Unplanned detonation on bunker firing table, in CFF firing chamber, or in CFF gray area with personnel present: Electrical input from unplanned source. Detonation caused by fire Induced short in energized cables co located with detonator cables

		DET CABLES	LICT CLICDT ON			En	d State
FIRE IN VICINITY OF DET CABLES	FIRE EXTINGUISHED	ROUTED TOGETHER WITH ENERGIZED CABLES	HOT SHORT ON ENERGIZED CABLE	EVACUATION BEFORE DETONATION	No.	Annual Probability	Description
		CABLES	·	L	140.		Description
	Fire extinguished				1		NO DETONATION
Fire in vicinity of Detonation cables	J	Cables not routed togeth	er		2	****	NO DETONATION
medium	Fire not extinguished		No Hot Short		3		NO DETONATION
	medium	Cables routed together medium		Personnel evacuation in time	4	extremely unlikely	DETONATION – PERSONNEL UNDER COVER
		·	Hot Short medium	high Personnel not evacuated in time	5	incredible	DETONATION – MULTIPLE INJURIES OR DEATH
				low			

Fig B.5 – SAR Scenario C3. Unplanned detonation on bunker firing table, in CFF firing chamber, or in CFF gray area with personnel present: Electrical input from unplanned source. Lightning imparts sufficient energy to fire detonators or to directly initiate HE.

	CARLED TO		LIGHTNING			En	d State
LIGHTNING DURING HE OPERATIONS	CABLES TO DETONATORS GROUNDED OR SHORTED	FIELD SUFFICIENT TO DETONATE	WARNING SYSTEM ALERTS PERSONNEL	PERSONNEL EVACUATE IN TIME	No.	Annual Probability	Description
		Field Insufficient to Deta	onate		1_		No Injuries/ Deaths
	Cables to Detonators		Lightning	Evacuation In Time	2	low	Detonation Personnel Under Cover
-	Grounded high	Field Sufficient	Warning System Alerts Personnel	hìgh			·
Lightning		To Detonate low	high	Evacuation Not In Time	3	extremely unlikely	Detonation Injuries/ Deaths
During He Operations			Warning System Fails to Alert Personnel	low	4	extremely unlikely	Detonation Injuries/ Deaths
high			low				-
	-	Field Insufficient to Det	onate		5		No Injuries/ Deaths
	Cables to Detonators Not		Lightning	Evacuation In Time	6	low	Detonation – Personnel Under Cover
	Grounded_ low	Field Sufficient	Warning System Alerts Personnel	High			
		To Detonate high	high	Evacuation Not In Time	7_	extremely unlikely	Detonation Injuries/ Deaths
			Warning System Fails to Alert Personnel	low	8	extremely unlikely	Detonation Injuries/ Deaths
			low				

Fig B.6 – SAR Scenario D. Unplanned detonation on bunker firing table, or in CFF firing table chamber with personnel present: Chemical reaction with assembly materials either detonates or sensitizes such that normal operation detonates HE.

	CHEMICAL	SHOT USES	CHEMICAL	DOCUMENTED	DESIGN REVIEW		En	d State
NORMAL SHOT	EXPOSURE TO HE IN CFF	NEW CHEMICAL	COMPATIBILITY	CHEMICAL INCOMPATIBILITY	DETECTS INCOMPATIBILITY	No.	Annual Probability	Description
	HE not exposed to	chemicals				1		NORMAL SHOT NO INJURIES OR DEATH
		Shot does not use r	new chemical			2		NORMAL SHOT NO INJURIES OR DEATH
NORMAL SHOT	HE exposed to		Chemical compatib	le		3_		NORMAL SHOT NO INJURIES OR DEATH
	chemicals medium	Shot uses new chemical high	Chemical is incompatible, HE sensitized medium	Chemical incompatibility documented high	Design Review detects incompatibility Design Review does not detect incompatibility low Design Review detects	5	extremely unlikely	NORMAL SHOT NO INJURIES OR DEATH HE SENSITIZED PREMATURELY DETONATES INJURIES/DEATHS NORMAL SHOT
				Incompatibility poorly documented or unknown medium	Design Review does not detect incompatibility medium	7	extremely unlikely	NO INJURIES OR DEATH HE SENSITIZED PREMATURELY DETONATES INJURIES/DEATHS

Fig B.7 – SAR Scenario E. Unplanned detonation on bunker firing table, in CFF firing chamber, or in CFF gray area with personnel present: Preconditioning heater or laser detonates or sensitizes such that normal operation detonates HE.

OPERATIONS INVOLVING HE		DEDUNDANT	· · · · · · · · · · · · · · · · · · ·	4		En	d State
HEATING OR USE OF HIGH POWERERED LASER	POWER CONTROL CIRCUIT STATUS	REDUNDANT TEMPERATURE MONITORING	HE SENSITIVITY TO OVER- TEMPERATURE	INSULT MECHANICAL	No.	Annual Probability	Description
ODEDATIONS	Control circuits work			_	11		NO DETONATION
OPERATIONS INVOLVING HE HEATING OR USE OF HIGH		Redundant temperature	monitoring works		2		NO DETONATION
POWERERED LASER high			HE remains unsensitize	d	3		NO DETONATION
nign	Power Control for	REDUNDANT		No Insult	4		NO DETONATION
	heating HE fails ON low	TEMPERATURE MONITORING FAILS low	Heat sensitizes HE high	Insult sufficient to cause detonation	5	incredible	DETONATION INJURIES/ DEATHS
			low Sufficient heating to cause detonation			incredible	DETONATION INJURIES/ DEATHS
			low HE remains unsensitize	ed	7		NO DETONATION
				No insult	8		NO DETONATION
	Power Control Circuit for Laser fails ON low		Heat sensitizes HE high	Insult sufficient to cause detonation	9	extremely unlikely	DETONATION INJURIES/ DEATHS
			Sufficient heating to ca	low use detonation	10	extremely unlikely	DETONATION INJURIES/ DEATHS
			low				

Fig B.8 – SAR Scenario G1. Detonation on bunker firing table, in CFF firing table chamber with personnel present: Electrical or laser light input from plannned source – Authorized personnel fail to muster before shot.

CONTROLLED	DEDOONNE	PERSONNEL	WITEDOOM ALEDTO	RUN SAFE		En	d State
CONTROLLED FIRE	PERSONNEL UNDER COVER	DETECTED DURING LOCAL MUSTER	INTERCOM ALERTS PERSONNEL	ACTUATED	No.	Annual Probability	Description
	Personnel Under Cover						NO INJURIES/DEATHS
Firing Procedure		Personnel Detected Dur	ring Local Muster				NO INJURIES/DEATHS
high	Personnel Not Under Cover		Intercom Alerts	Run Safe Actuated			NO INJURIES/DEATHS
	low	Personnel Not Detected During Local	Personnel high	Run Safe NOT actuated		Extremely Unlikely	DETONATION INJURIES/DEATHS
		Muster	Intercom Does Not Alert Personnel	medium		Incredible	DETONATION INJURIES/DEATHS
,			low				

Fig B.9 – SAR Scenario G2. Detonation on bunker firing table, in CFF firing table chamber with personnel present: Electrical or laser light input from plannned source – Detonators inadvertently fired before muster.

	CABLES TO	VOLTAGE AT	OPERATOR	CDU CHARGED		En	d State
DETONATORS CONNECTED TO FIRING CABLES	DETONATORS CONNECTED TO CDU PRIOR TO MUSTER	CDU OUTPUT WHEN CABLES ARE CONNECTED	DETECTS VOLTAGE AT CDU OUTPUT	AND FIRED BEFORE MUSTER	No.	Annual Probability	Description
	Cables to detonators Gr	ounded. Safe Condition			11		NO INJURIES/DEATHS
Detonators Connected to Firing	·		Operator Detects Voltace	qe	2		NO INJURIES/DEATHS
Cables	Cables to Detonators Connected To CDU Before	Voltage Present low	Operator Fails to Detec	t Voltage	3	incredible	DETONATION INJURIES/DEATHS
	Muster		low	Personnel Muster Before Fire	4		INJURIES/DEATHS
		Voltage Not Present high	·	CDU Charged And Fired Before Muster	5	incredible	DETONATION INJURIES/DEATHS
				low		·	

Fig B.10 – SAR Scenario G.2A Detonation on bunker firing table, in CFF firing chamber with personnel present: Electrical or laser light input from planned source -- unauthorized personnel in mustering area

		TRACKING SYSTEM	MUSTERING SWEEP		En	d State
NORMAL FIRE	UNAUTHORIZED PERSONS IN MUSTERING AREA	DETECTS UNAUTHORIZED PERSONS IN MUSTERING AREA	DETECTS UNAUTHORIZED PERSONS IN AREA	No.		Description
	NO UNAUTHORIZED PERSO	NS IN MUSTERING AREA		1	·	NO INJURIES/ DEATHS
NODWAL FIDE		TRACKING SYSTEM DETECTS UNAUTHORIZED F AREA	PERSONS IN MUSTERING	2		NO INJURIES/ DEATHS
NORMAL FIRE high	UNAUTHORIZED PERSONS IN MUSTERING AREA	TRACKING SYSTEM FAILS	MUSTERING SWEEP DETECTS UNAUTHORIZED PERSONS IN AREA	3		NO INJURIES/ DEATHS
	low	TO DETECT UNAUTHORIZED PERSONS IN MUSTERING AREA medium	MUSTERING SWEEP FAILS TO DETECT		. •	
			UNAUTHORIZED PERSONS IN AREA low	4	extremely unlikely	INJURIES/ DEATHS

Fig B.11– SAR Scenario H. Unplanned detonation on bunker firing table, or in CFF firing chamber with personnel present: Detonation of unreacted HE after shot.

UNREACTED	HE HAZARD	TIME DELAY	REMOTE	WORKER			En	d State
HE FROM SHOT	PROPERTIES	ELIMINATES HAZARD	MONITORING	INSPECTION	RECOVERY	No.	Annual Probability	Description
	NO HAZARD				-	1		NO INJURIES/ DEATHS
		- - 11.						NO INJUNIES/ DEATHS
		TIME DELAY ELIM	NATES HAZARD			2		NO INJURIES/ DEATHS
UNREACTED HE								
high					RECOVERY SUCCESSFUL	3		NO INJURIES/ DEATHS
	POTENTIAL		REMOTE M SUCCE	ONITORING				
!	HAZARD medium	TIME DELAY DOES NOT ELIMINATE		gh	RECOVERY UNSUCCESS- FUL	4	Extremely Unlikely	DETONATION INJURIES/ DEATHS
	ļ	HAZARD medium			low RECOVERY SUCCESSFUL	5		NO INJURIES/ DEATHS
	·			WORKER INSPECTION SUCCESSFUL high	RECOVERY UNSUCCESS- FUL	6	Incredible	DETONATION INJURIES/ DEATHS
			REMOTE MONITORING UNSUCCESS- FUL		low			
			low	WORKER INSPECTION	RECOVERY SUCCESSFUL	7		NO INJURIES/ DEATHS
				UNSUCCESS- FUL				
				low	RECOVERY UNSUCCESS- FUL low	8	Incredible	DETONATION INJURIES/ DEATHS

Fig B.12 - SAR Scenario N. Personnel exposed to toxic material above exposure limits or oxygen deficient atmosphere in facility after test (CFF

only).

	GAS CONTAIN- MENT SYSTEMS	VISUALLY	GAS	VISUAL	TIMELY		En	d State
CFF SHOT		DETECT GAS LEAK	MONITOR READINGS	INSPECTION UPON ENTRY	DETECTION AND EVACUATION	No.	Annual Probability	Description
	PURGE	VISUALLY DETECT	ΓGAS LEAK			1_1_		NO INJURIES/ DEATHS
	SYSTEM FAILS		PERSONNEL OBS	ERVE GAS MONITO	R READINGS	2		NO INJURIES/ DEATHS
•	low	NO VISUAL DETECTION	FAIL TO	VISUAL INSPECTI	ON MADE	3	-	NO INJURIES/ DEATHS
		medium OBSERVE GAS MONITOR READ		FAIL TO PERFORM VISUAL		4	incredible	DETONATION INJURIES/ DEATHS
		VISUALLY DETEC	medium			5		NO INJURIES/ DEATHS
	VENT SYSTEM NOT ISOLATED low NO VISUAL DETECTION medium		PERSONNEL OBSERVE GAS MONITOR READINGS		. 6		NO INJURIES/ DEATHS	
CFF SHOT high		DETECTION FAIL TO	VISUAL INSPECTI	ON MADE	7		NO INJURIES/ DEATHS	
		medium	medium OBSERVE GAS MONITOR READ low	FAIL TO PERFORI		8	incredible	DETONATION INJURIES/ DEATHS
		medium PERSONNEL OBSERVE GAS MONITOR READINGS						NO INJURIES/ DEATHS
	PURGING TO A SAFE CHAMBER medium		FAIL TO	VISUAL INSPECT	ON MADE	10	·	NO INJURIES/ DEATHS
·	modiani		OBSERVE GAS MONITOR READ		J. T. T. T. T. T. T. T. T. T. T. T. T. T.	10		NO INCOMEDIATION
			low	FAIL TO PERFORM VISUAL INSPECTION LIPON ENTRY		11	extremely unlikely	DETONATION INJURIES/ DEATHS
			medium PERSONNEL OBSERVE GAS MONITOR READINGS			12		NO INJURIES/ DEATHS
	REDUNDANT PENETRATIONS FAIL		DETECTION &EVACUATION		13		NO INJURIES/ DEATHS	
	low	low		L TO OBSERVE EADINGS	PERSONNEL FAIL TO EVAC- UATE IN TIME	14	extremely unlikely	DETONATION INJURIES/ DEATHS
					medium		unincery	MOONICO/ DEATHO

Fig B.13 – SAR Scenario O. Camera room port breaches, exposing personnel inside of facility to blast effects.

	SHOT LENS	REDUNDANT SHOT	PERSONNEL	DETECT	End State		
NORMAL SHOT	INTEGRITY	LENS INTEGRITY	UNDER COVER	PERSONNEL NOT UDER COVER	No.	Annual Probability	Description
	Shot lens integrity				1		NO INJURIES/ DEATHS
NORMAL SHOT		Redundant shot lens int	tegrity		2		NO INJURIES/ DEATHS
	Shot lens integrity fails low		Personnel under cover		3		NO INJURIES/ DEATHS
		Redundant shot lens integrity failure medium		Detect personnel under cover	4		NO INJURIES/ DEATHS
			Personnel not under cover	Failure to detect			
			· IOW	personnel not under cover medium	5	extremely unlikely	INJURIES/ DEATHS
				,,,odidin			

Fig B.14 – **SAR Scenario P.** Personnel exposed to toxic gas or oxygen deficient atmosphere in firing chamber, camera room or diagnostic equipment penetration room (CFF only).

		I SYSTEM I	0.10.00/07514	EVACUATION GIVEN GAS SYSTEM LEAK	End State			
GAS SYSTEM PRESSURIZED	GAS SYSTEM INTEGRITY		GAS SYSTEM MONITORING	AND GAS MONITORING FAILURE	No.	Annual Proability	Description	
	Gas system intact				1		NO INJURIES/DEATHS	
Gas System Pressurized high		Ventilation system remo	oves hazard	٠.	2		NO INJURIES/DEATHS	
ngn	Gas system leaks low	Ventilation system	Gas system monitoring	detects leak	3_		NO INJURIES/DEATHS	
	iow	does not remove hazard	·	Personnel detects leak and evacuates in time	4		NO INJURIES/DEATHS	
			Gas Monitoring System Fails to detect Leak low	Failure to evacuate personnel in time	5	Incredible	ASPHYXIATION OR TOXICOSIS INJURIES/DEATHS	
				medium				

Fig B.15 – SAR Scenario Q. Personnel exposed to beryllium shrapnel or contamination in camera room.

CAMEDA	ROTOR	CAMERA CASE PERSONNEL		DETECT	End State		
CAMERA OPERATION	INTEGRITY	CONTAINS ROTOR	UNDER COVER	PERSONNEL NOT UNDER COVER	No.	Annual Probability	Description
	Rotor does not fail				1		NO INJURIES/DEATHS
camera operation		Camera case contains r	rotor		2		NO INJURIES/DEATHS
high	Rotor failure		Personnel under cover		3		NO INJURIES/DEATHS
	low	Camera case fails to contain rotor medium		Detect personnel not under cover	4		NO INJURIES/DEATHS
			Personnel not under cover medium	Failure to detect personnel not under cover	5	extremely unlikely	INJURIES/DEATHS
·				low			

Fig B.16 – SAR Scenario T. Personnel under cover during CFF test exposed to blast effects.

	STRUCTURAL	REDUNDANT	OFFICE I DEDCOMMENT	DETECT	End State			
CFF SHOT	INTEGRITY OF CFF	BARRIER UNDER COVER INTEGRITY	PERSONNEL NOT UNDER COVER	No.	Annual Probability	Description		
			Personnel under cover		1		NO INJURIES/ DEATHS	
				Detect personnel not under cover	2		NO INJURIES/ DEATHS	
	CFF structural	high	Personnel not under cover				·	
	integrity fails low		low	Failure to detect personnel not under cover	_ 3	Extremely Unlikely	INJURIES/ DEATHS	
	1	Redundant barrier fails		medium	4	Extremely		
		low						
	ŀ	Redundant penetration	protection holds	5		NO INJURIES/ DEATHS		
CFF Shot	Shot effects fail penetration low							
high	1	Redundant penetration	protection fails		_ 6	Extremely		
	low					Unlikely		
			Personnel under cover		7		NO INJURIES/ DEATHS	
		Redundant barrier maintains integrity		Detect personnel not under cover	8		NO INJURIES/ DEATHS	
	low	Personnel not under cover						
	Blast doors not secure	1	low	Failure to detect personnel not under	9	Incredible	INJURIES/ DEATHS	
			s. Barriers include labvrin	medium th and wall	10	Extremely	INJURIES/ DEATHS	
		lov	V		į	Unlikely		

Fig B.17 - SAR Scenario U. Exposure of personnel on firing table, in magazine or other structure to highly toxic material in experiment: Container leaks due to design or human error in assembly or filling process

OPERATIONS W/	CONTAINER		DIRECTION OF AIR	End State			
ASSEMBLY HIGHLY TOXIC MATERIAL	INTEGRITY	LEAK DETECTION	FLOW	No.	Annual Probability	Description	
	CONTAINER INTEGRITY MAINTAINED			1		NO EXPOSURE ABOVE LIMITS	
OPERATIONS – (e.g. handling, transportation) high	CONTAINER BREACHED- DESIGN/HUMAN ERROR Iow	LEAK DETECTED BY MONITORS OR ODOR		2		NO EXPOSURE ABOVE LIMITS	
			AIR FLOW MOVES MATERIAL AWAY FROM PERSONNEL	3	·	NO EXPOSURE ABOVE LIMITS /MINOR EXPOSURE	
		LEAK NOT DETECTED BY MONITORS OR ODOR low	AIR FLOW MOVES MATERIAL TOWARD PERSONNEL	4	Extremely Unlikely	SERIOUS ILLNESS/DEATH TO WORKERS AND COLOCATED WORKERS FOR UP TO ~ 150 METERS DOWNWIND	
			medium			<u> </u>	

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